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AID Report 62-175 13 November 1962

ITEM OF INTEREST

Prepared by

Aerospace Information Division
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SUBJECT: Effect of the Earth's Rotation on Atmospheric and Hydrospheric Processes

SOURCE: Sidorenkov, N. S. Effect of the nonuniform rotation of the earth on atmospheric and hydrospheric processes. IN: Arkticheskiy i antarkticheskiy nauchno-issledovatel'skiy institut. Problemy arktiki i antarktiki; sbornik statey, vyp. 9 (Problems of the Arctic and Antarctic; collection of articles, no. 9). Leningrad, Izd-vo Morskoy transport, 1961. 45-49.

At the present time, three types of variation in the angular velocity of the Earth's rotation are known: secular retardation, irregular "staggered" fluctuations, and periodical seasonal variations. From observations conducted in the years 1937 through 1949, it was found that the annual variation in the length of a day (from the shortest in July and August to the longest in March) averaged 0.0025 sec; that is, the diurnal increase in the length of a day δT is $\pm 1.4 \cdot 10^{-8}$ sec.

The rotary motion of a planetary sphere determines its ellipticity. The ellipticity varies under the influence of definite increments of centrifugal forces, which ultimately lead to the redistribution of the mass of the sphere. These additional deforming forces, broken down for practical purposes into vertical (normal) and horizontal (tangential) components, were found to approximate

$$\delta F_N \cong \frac{2}{3} \omega r(1 - 3 \sin^2 \varphi) \delta\omega; \quad (1)$$

$$\delta F_\tau \cong \omega r \sin 2\varphi \delta \omega; \quad (2)$$

where ω is the angular velocity of the earth's rotation, r is the radius vector of the ellipsoid, φ is the geocentric latitude, δF_N is the increment of the vertical deforming force, and δF_τ is the increment of the horizontal deforming force.

Table 1. Diurnal increases of various characteristics as functions of latitude

Lat.	δF_N (dynes)	δF_τ (dynes)	δP (mb)	v (m/sec)	δH (cm)	ΔP (mb)	$\Delta v'$ (m/sec)
0°	$5{,}40 \cdot 10^{-10}$	0	$5{,}40 \cdot 10^{-10}$	$1{,}08 \cdot 10^{-7}$	$-3{,}51 \cdot 10^{-4}$	2,32	464
10°	$4{,}91 \cdot 10^{-10}$	$2{,}78 \cdot 10^{-10}$	$4{,}91 \cdot 10^{-10}$	$1{,}06 \cdot 10^{-7}$	$-2{,}97 \cdot 10^{-4}$	2.10	456
20°	$3{,}48 \cdot 10^{-10}$	$5{,}21 \cdot 10^{-10}$	$3{,}48 \cdot 10^{-10}$	$1{,}02 \cdot 10^{-7}$	$-2{,}27 \cdot 10^{-4}$	1.50	436
30°	$1{,}31 \cdot 10^{-10}$	$7{,}01 \cdot 10^{-10}$	$1.31 \cdot 10^{-10}$	$0{,}94 \cdot 10^{-7}$	$-0.80 \cdot 10^{-4}$	0.56	401
35°	$-0{,}02 \cdot 10^{-10}$	$7{,}62 \cdot 10^{-10}$	$-0.02 \cdot 10^{-10}$	$0.88 \cdot 10^{-7}$	$0.01 \cdot 10^{-4}$	−0,01	380
40°	$-1{,}34 \cdot 10^{-10}$	$7{,}95 \cdot 10^{-10}$	$-1.34 \cdot 10^{-10}$	$0.83 \cdot 10^{-7}$	$0.85 \cdot 10^{-4}$	−0.58	356
45°	$-2{,}74 \cdot 10^{-10}$	$8{,}06 \cdot 10^{-10}$	$-2.74 \cdot 10^{-10}$	$0.77 \cdot 10^{-7}$	$1.77 \cdot 10^{-4}$	−1.18	329
50°	$-4{,}14 \cdot 10^{-10}$	$7{,}93 \cdot 10^{-10}$	$-4.14 \cdot 10^{-10}$	$0{,}70 \cdot 10^{-7}$	$2.68 \cdot 10^{-4}$	−2.44	298
60°	$-6{,}76 \cdot 10^{-10}$	$6{,}95 \cdot 10^{-10}$	$-6.76 \cdot 10^{-10}$	$0{,}54 \cdot 10^{-7}$	$4.39 \cdot 10^{-4}$	−2.90	232
70°	$-8{,}38 \cdot 10^{-10}$	$5{,}93 \cdot 10^{-10}$	$-8.38 \cdot 10^{-10}$	$0.37 \cdot 10^{-7}$	$5.78 \cdot 10^{-4}$	−3.96	159
80°	$-10{,}20 \cdot 10^{-10}$	$2{,}90 \cdot 10^{-10}$	$-10.20 \cdot 10^{-10}$	$0.19 \cdot 10^{-7}$	$6.33 \cdot 10^{-4}$	−4.38	80
90°	$-10{,}70 \cdot 10^{-10}$	0	$-10.70 \cdot 10^{-10}$	$0.00 \cdot 10^{-7}$	$7.00 \cdot 10^{-4}$	−4.60	0

Considered separately from other effects, the following two atmospheric processes may result from the rotation of the earth:

1) Variations of air pressure δP due to the increment of the vertical deforming force, δF_N:

$$\delta P = c \int_0^\infty \delta F_N \, \rho \, dz, \tag{3}$$

where c is a parameter dependent on the physical properties of the atmosphere, and ρ is air density. Equation (3) indicates that increases in the angular velocity of the earth's rotation cause positive increases in pressure from latitude $\pm 35°$ toward the poles and negative increases from latitude $\pm 35°$ toward the equator. When angular velocity decreases, the picture is reversed. The extreme values of the increasing pressure δP are reached at the poles and the equator. At latitude $\pm 35°$, $\delta P = 0$.

2) Emergence of a component of air-current velocity due to the increment of the horizontal deforming force δF_τ:

$$v = \frac{\delta F_\tau}{2\,\omega \, \sin \varphi} \cong r \cos \varphi \delta \omega. \tag{4}$$

East-west currents are generated during the increase of the angular velocity and west-east currents during the decrease.

For the hydrosphere, variations in the earth's rotation may result in 1) emergence of a component of the velocity of water mass currents and 2) variation of the ocean level due to the greater mobility of water masses as compared to subcrustal plastic matter. On the assumption that the radius of the lithosphere remains constant in a varying rotary motion, the increments of the world ocean level δH may be computed from the expression

$$\delta H = -\frac{2}{3} k \frac{R \cdot \alpha}{\omega} (1 - 3 \sin^2 \varphi) \delta\omega \tag{5}$$

where k is the dimensionless parameter of the order of a unit, R is the mean radius of ellipsoid, and α is the compression of the ellipsoid. The α value is determined by the relationship

$$\alpha = \frac{Rh}{2g} \omega^2,$$

where g is gravity acceleration, and h is a constant dependent on the structure of the ellipsoid under consideration.

Quantitative computations show that processes caused by variations of the earth's rotation are too insignificant to explain the existing peculiarities of the general circulation of either the atmosphere or hydrosphere.